IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

In re the application of:
HUI-JUNG WU, ET AL.

Docket: 30-4731 (4780) DIV-1

Serial Number: 09/841,453

Group Art Unit: 2829

Filed: April 24, 2001

Examiner: Asok K. Sarkar

For: USE OF MULTIFUNCTIONAL SI-BASED OLIGOMER/POLYMER FOR THE SURFACE MODIFICATION OF NANOPOROUS SILICA FILMS

APPEAL BRIEF FOR APPELLANT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

This is an Appeal to the Board of Patent Appeals and Interferences from the Final Rejection of claims 2-29 and 31-34 mailed April 23, 2003 in the above identified case. A Notice of Appeal is being filed concurrently herewith. An oral hearing is not requested. This Brief is hereby filed in triplicate.

It is believed that **no** additional Appeal Brief fee is required for this submission because an Appeal Brief fee was already submitted in this application in conjunction with an Appeal Brief entered on January 2, 2003.

If the Commissioner determines than an Appeal Brief fee is required, the Commissioner is authorized to charge the required Appeal Brief fee of $320.00 to Deposit Acct. No. 01-1125. In the event that the Commissioner determines that an additional extension of time is required in order for this submission to be timely, it is requested that this submission include a petition for an additional extension for the required length of time and the Commissioner is authorized to charge any other fees necessitated by this paper to Deposit Acct. No. 01-1125.

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I. REAL PARTY IN INTEREST

The real party in interest is Honeywell International, Inc., the assignee of record.

II. RELATED APPEALS AND INTERFERENCES

With respect to other appeals or interferences that will directly affect, or be directly affected by, or have a bearing on the Board's decision in this appeal, please note that parent application serial number 09/488,075 is on appeal. There are no other related applications on appeal or subject to an interference known to appellant, appellant's legal representative or the assignee.

III. STATUS OF CLAIMS

The claims in the application are 2-34. Claims 2-29 and 31-34 are pending, stand rejected and are on appeal. Claim 30 has been withdrawn from consideration. No claims are allowed.

IV. STATUS OF AMENDMENTS

An amendment in response to the final rejection is being filed concurrently herewith, to cancel claim 30 without prejudice.

V. SUMMARY OF THE INVENTION

Concise explanation of the invention defined in the claims involved in the appeal, which refer to the specification by page and line number:

The present invention relates to a nanoporous silica film produced by a process comprising the steps of reacting a suitable silica film with a composition comprising a surface modification agent, wherein said silica film is present on a substrate and wherein said reaction is conducted under conditions and for a period of time sufficient for said surface modification agent to form a hydrophobic coating on said film and said surface

modification agent comprises at least one type *of oligomer or polymer reactive with silanol groups* on said silica film.

Specification reference for this concise explanation may be found at page 4, line 5 through page 6, line 10. The process of reacting silanol groups with the surface modifying oligomer or polymer to impart hydrophobicity for the silica film on a substrate may be found in the specification at page 6, line 11 through page 22, line 29, particularly at page 14, line 9, et seq.

VI. <u>ISSUES</u>

(a) Whether claims 2-16, 18-21, and 31-34 are unpatentable under 35 U.S.C. 103 over Jin in view of Grainger and Kotelnikov.

(b) Whether claims 22-29 are unpatentable under 35 U.S.C. 103 over Jin in view of Grainger and Kotelnikov.

(c) Whether claim 17 is unpatentable under 35 U.S.C. 103 over Jin in view of Grainger and Kotelnikov, and in further view of Burns.

(d) Whether claims 2-29 and 31-34 are unpatentable under the judicially created doctrine of obviousness-type double patenting over claims 1-19 of Rutherford et al. (US 6,318,124) in view of Grainger and Kotelnikov.

VII. <u>GROUPING OF CLAIMS</u>

The claims do not all stand or fall together, but only stand or fall together within the following groupings of claims.

Group I: Claim 2, directed to the reaction being conducted in the presence of at least one solvent or co-solvent.

Group II: Claims 3 and 4, directed to the structure of the silica film, and to the reaction parameters in order to produce a treated nanoporous silica film having a particular dielectric constant.

Group III: Claim 5, directed to the temperature range of the reaction.

Group IV: Claim 6, directed to the reaction time.

Group V: Claim 7, directed to the makeup of the surface modification agent.

Group VI: Claims 8, 11-14, 17, directed to the preparation of the surface modification agent of claim 7.

Group VII: Claims 9 and 10, directed to the makeup of the solvent or co-solvent.

Group VIII: Claim 15 and 18-19, directed to the makeup of the composition of claim 20.

Group IX: Claim 16, directed to the pre-treatment of the silica film with a monomer surface modification agent, wherein said monomer is reactive with silanol groups on said silica film.

Group X: claim 20, the independent article claim relating to the nanoporous silica film of the invention.

Group XI: claim 21, directed to stud-test results of the silica film.

Group XII: claim 22, the independent article claim relating to an integrated circuit comprising a nanoporous silica film of the invention.

Group XIII: claim 23 and 26-29 directed to the preparation of the surface modification agent of claim 22.

Group XIV: claims 24-25, directed to the makeup of the solvent or co-solvent.

Group XV: claims 31-34, directed to the surface modification agent of claim 20.

VIII. ARGUMENTS

The examiner has rejected claims 2-16, 18-21, and 31-34 under 35 U.S.C. 103 over Jin (EP 08 49796) in view of Grainger (U.S. patent 5,686,549) and in further view of Kotelnikov (RU 2089499). It is respectfully asserted that this ground of rejection should be overruled

The present claims are directed to a *nanoporous silica film* produced by a process comprising the steps of reacting a suitable silica film on a substrate, with a surface modification agent to form a *hydrophobic coating on said film* and wherein the surface modification agent comprises at least one type of *oligomer or polymer* reactive with silanol groups on said silica film.

The examiner asserts that Jin et al. teaches several features of the presently claimed invention. Indeed, Jin et al. discloses dielectric materials comprising an organic silica dielectric on a surface. Further, Jin et al's pore surfaces may be rendered hydrophobic by rinsing with a *monomeric* material such as hexamethyldisilazane (HMDS). However, as the examiner admits, Jin *fails* to teach a surface modification agent which is an *oligomer or polymer*. Such is required by the present claims. Instead, Jin et al.'s reaction with monomeric HMDS serves to cap the silanols by forming trimethylsilyl groups which are significantly less polarizable than the original silanols of the silica, and render the pore

surfaces of the film hydrophobic. This is disadvantageous because the use of trimethylsilyl groups are not very thermally stable and may out-gas during processing of interconnect structures and cause via poisoning.

The Examiner attempts to fill these deficiencies by citing Grainger and Kotelnikov. However, Applicants respectfully urge that there is no teaching or suggestion in either Grainger or Kotelnikov which would lead one skilled in the art to combine these references with Jin in an effort to devise the present invention.

The examiner attempts to use Grainger to teach the use of an oligomer/polymer to impart hydrophobicity on a surface. Grainger relates to polymers which form ultrathin polymeric films which are bonded onto a substrate surface, to thereby impart various useful properties onto the surface. Indeed, one such property includes hydrophobicity. However, Applicants urge that Grainger fails to teach the formation of a *nanoporous silica* film on a substrate, wherein the pore surfaces of the film are rendered hydrophobic, as required by the present invention. Rather, Grainger teaches the formation of film on a *solid substrate surface*, followed by the imparting of hydrophobicity to the *substrate*. Furthermore, nowhere does Grainger teach the formation of a *porous* film which is hydrophobized, let alone a *nanoporous silica* film. In addition, Applicants submit that Grainger's long polymeric molecules formed by a Langmuir-Blodgett technique, for imparting hydrophobicity to the substrate *would not fit* into a pore structure of a nanoporous film, and thus would not be useful with the present invention. Thus, it is submitted that one skilled in the art would not look to the teachings of Grainger in an effort to devise the presently claimed invention.

Regarding Kotelnikov, it is further urged that the examiner is citing non-analogous art. Kotelnikov et al. relates to the oil and gas industry. It teaches the production of a material for use in oil and gas wells, for changing the oil- and water- permeability of strata formed in such wells. The material formed according to this reference is applied onto elements of oil-gas complexes to increase their resistance to aggressive media, corrosion, icing, and biological growth. This material taught by Kotelnikov is based on silica or metal oxide

which is activated with carbonates of alkali metals and is then chemically modified with an organometallic compound at an elevated temperature. The result of this process is then additionally chemically modified by using an elemental-organic compound of formula $Cl_{4-n}SiR_n$, where n is 1-3, and R is H, methyl-, ethyl-, Cl-methyl-, or phenyl-, and followed by an additional treatment with a compound selected from the group including tetramethoxysilane, tetraethoxysilane, or an oligomer of polymethyl(ethyl)siloxane, or polymethyl silazane, in an amount from 0.5 to 1.0 weight percent. This reference clearly does not teach any starting material which is a nanoporous silica film on a substrate, having silanols on said silica film, as required by the present invention.

It is urged that there is no teaching or suggestion in the cited references which would lead one skilled in the art to combine Kotelnikov with Grainger with Jin. Not only would those skilled in the art not look to combine these cited references, but it is also submitted that such a combination would still fail to obviate the present claims, as amended. The Examiner appears to be going to great lengths to locate and try to interrelate various references, but no matter how one applies or combines these references they do not teach the claimed invention. Thus, Applicants respectfully submit that the 35 U.S.C. 103 rejection should be withdrawn.

The examiner has rejected claims 22-29 under 35 U.S.C. 103 over Jin (EP 08 49796) in view of Grainger (U.S. patent 5,686,549) and in further view of Kotelnikov (RU 2089499). It is respectfully asserted that this ground of rejection is improper.

The arguments for Jin, Granger, an Kotelnikov are repeated from above and apply equally herein. As stated above, each of these references fails to teach key features of the presently claimed invention. Jin *fails* to teach a surface modification agent which is an *oligomer or polymer*; Grainger fails to teach the formation of a *nanoporous silica* film on a substrate, wherein the pore surfaces of the film are rendered hydrophobic; and Kotelnikov, which is *completely non-analogous art,* does not teach a starting material which is a silica film on a substrate, having silanols on said silica film. Applicants urge that there is no teaching or

suggestion in *any* of these cited references which would inspire one skilled in the art to combine these references in an effort to formulate the claimed invention. When selective combination of prior art references is needed to make an invention seem obvious, there must be something in the art to suggest that particular combination other than hindsight gleaned from the invention itself, something to suggest the desirability of the combination. Uniroyal, Inc. v. Rudkin-Wiley Corp., 5 U.S.P.Q.2d 1434, 1438 (CAFC 1988). Such a suggestion is absent in the cited references. Furthermore, it is urged that such a combination would still fail to obviate the present claims. For these reasons and for the reasons argued for the rejection of claims 2-16 and 18-21 above, it is submitted that the rejection should be overruled.

The examiner has also rejected claim 17 under 35 U.S.C. 103 over Jin (EP 08 49796) in view of Grainger (U.S. patent 5,686,549), in further view of Kotelnikov (RU 2089499), and in further view of Burns (U.S. patent 5,750,610). Applicants respectfully submit that this ground of rejection is not proper.

The arguments for Jin, Grainger, an Kotelnikov are repeated from above and apply equally herein. The Burns reference teaches the formation of hydrophobic organosilicate modified silica gels. However, it fails to teach a film on a substrate and importantly fails to teach or suggest an *oligomer or polymer* which is reactive with silanol groups on any such silica film. In fact, Burns et al. does not teach or suggest a surface modification agent at all, much less an *oligomer or polymer* which is reactive with silanol groups on a silica film.

The agents used by Burns, et al have the Formulas (I) or (II) on column 3, lines 25, et seq. and are enumerated on col. 6 line 3 through 52. Please note that both the generic formulas and each individual species pertains to a *monomer, not an oligomer or polymer* and certainly not an oligomer or polymer reactive with silanol groups on a silica film. The examiner apparently believes that because some of these monomers are mentioned to be high molecular weight, that they are thereby construed to oligomers or polymer. This is *not the case.* The examiner specifically points to column 7, lines 36-40 of Burns, et al for the

proposition that Burns, et al employ oligomers. However, these are not oligomers or polymers. The are monomers.

Indeed, some of these same monomers may be employed as precursors to *form* the polymers and oligomers of this invention (see claim 8 wherein the Applicant's surface modification agent is prepared by *reacting* a suitable monomer with water in a solvent to form said surface modification agent); they may be employed as an *additional* component together with the oligomer or polymer (see claim 15). However, their use in this manner does not detract from the fact that an oligomer or polymer surface modification agent is required by the claims and absent from Burns, et al.

In addition, Burns, et al does not teach a nanoporous silica film on a substrate, wherein the surface the silica film is to be hydrophobized. Rather, Burns et al. form a reaction product of a silica with an organosilane and a strong acid in a flask (see examples), to provide a hydrophobized reaction product. Such does not pertain to a coating on a substrate at all. Therefore Burns is to be considered non-analogous art to the modification of dielectric films on a substrate. The Examiner's approach seems to be to cite a string of references, figuratively throw all the ingredients of the reference teachings in one pot, and then pull out whichever ingredients are needed to reconstruct the claimed invention. How would one know which ingredients to combine absent the guidance provided in the present application? Where Applicants' teachings are needed to find the invention, the invention is not obvious. Obviousness is determined at the time the invention is made, not after reading Applicants' teaching. 35 U.S.C. 103. Citing references that merely indicate that isolated elements recited in the claims are known is not a sufficient basis for a conclusion of obviousness; there must be something that suggests the desirability of combining the references in a manner calculated to arrive at the claimed invention. Ex parte Hiyamizu, 10 U.S.P.Q.2d 1393, 1394 (PTO Bd. Pat. Ap. and Int., 1988).

For the above reasons, it is urged that one skilled in the art would not be imbued with an inspiration to formulate the presently claimed invention upon a combining of Jin, Grainger,

Kotelnikov, and Burns. Applicants therefore respectfully urge that the 35 U.S.C. 103 rejection be overruled.

The examiner has rejected claims 2-29 and 31-34 under the non-statutory, judicially created doctrine of obviousness-type double patenting over claims 1-19 of U.S. patent 6,318,124 (Rutherford et al.) in view of Grainger (U.S. patent 5,686,549) and in further view of Kotelnikov (RU 2089499). It is respectfully submitted that the rejection is not well taken.

The present invention relates to a *nanoporous silica film* produced by a process comprising the steps of *reacting* a suitable silica film *on a substrate*, with a surface modification agent to form a hydrophobic coating on said film and wherein the surface modification agent comprises at least one type of *oligomer or polymer* reactive with silanol groups on said silica film.

Rutherford et al. discloses a surface-coated nanoporous silica dielectric film in which a polymeric layer is deposited onto a silica dielectric film on a substrate. Rutherford, et al then may apply a *monomeric* surface modification agent such as those enumerated on column 8, lines 15, et seq. The surface of the nanoporous silica dielectric film is then coated with a polymer layer. However, none of the claims indicate that their surface modification agent is an oligomer or polymer *reactive with silanol groups* on a silica film. The Rutherford, et al coating materials are different than the surface modification agents within the scope of the claimed invention and do not form coatings on silica dielectric films as the claimed films in which surface modification agents which are *oligomer or polymer reactive with silanol groups on said silica film* and form a hydrophobic coating thereon.

As stated above, Grainger teaches the formation of ultrathin polymeric films which are bonded onto a substrate surface, to thereby impart hydrophobicity and the like to that surface. The examiner attempts to use Grainger to teach the use of an oligomer/polymer to

impart hydrophobicity on a surface. However, as stated above, Grainger fails to teach the formation of a *nanoporous silica* film on a substrate, wherein the pore surfaces of the film are rendered hydrophobic. Rather, Grainger teaches the formation of film on a *solid substrate surface*, followed by the imparting of hydrophobicity to the *substrate*. Furthermore, nowhere does Grainger teach the formation of a *porous* film which is hydrophobized, let alone a *nanoporous silica* film. It is further submitted that the long polymeric molecules used by Grainger for imparting hydrophobicity to the substrate *would not fit* into a pore of a nanoporous film, and thus would not be useful with the present invention.

As stated above, Kotelnikov et al. relates to the oil and gas industry. It teaches the production of a material for use in oil and gas wells, for changing the oil- and water-permeability of strata formed in such wells. The material taught by Kotelnikov is based on silica or metal oxide which is activated with carbonates of alkali metals and is then chemically modified with an organometallic compound at an elevated temperature. The result of this process is then additionally chemically modified by using an elemental-organic compound of formula Cl_4-nSiRn, where n is 1-3, and R is H, methyl-, ethyl-, Cl-methyl-, or phenyl-, and followed by an additional treatment with a compound selected from the group including tetramethoxysilane, tetraethoxysilane, or an oligomer of polymethyl(ethyl)siloxane, or polymethyl silazane, in an amount from 0.5 to 1.0 weight percent.

Kotelnikov certainly discloses the *use* of an oligomeric or polymeric surface modification agent, however is specifically teaches only injecting an oil well with a surface modification agent which is an oligomer or polymer. This reference clearly does not teach any starting material which is a silica film on a substrate, having silanols on said silica film, as required by the present invention. Thus, it is urged that one skilled in the art would not look to combine Kotelnikov with Grainger and/or Rutherford in an effort to devise the presently claimed invention.

Applicants urge that the present invention is materially different, and thus patentably distinct, from Rutherford et al. in view of Grainger and Kotelnikov. It is further urged that there is no teaching or suggestion in any of these references that would not have imbued one skilled in the art with an inspiration to devise the presently claimed invention upon a reading of the cited references. Applicants therefore respectfully submit that the obviousness-type double patenting rejection is improper and should be overruled.

None of the cited references, taken alone or in combination, teaches or suggests the invention claimed by Applicants. For all the above reasons, claims 2-29 and 31-34 are urged to be patentable over the cited references, and the rejections under 35 U.S.C.103 should be overruled.

Respectfully submitted,

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I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail, postage pre-paid in an envelope addressed to Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on July 18, 2003.

Richard S. Roberts

IX. APPENDIX

2. The nanoporous silica film of claim 20 wherein said reaction is conducted in the presence of at least one solvent or co-solvent.

3. The nanoporous silica film of claim 20, said silica having a pore structure that comprises silanols, and wherein said reaction is conducted for a period of time sufficient for said surface modification agent to produce a treated nanoporous silica film having a dielectric constant of about 3 or less.

4. The nanoporous silica film of claim 3 having a dielectric constant ranging from about 1.1 to about 3.0.

5. The nanoporous silica film of claim 20 wherein said reaction is conducted at a temperature ranging from about 10°C to about 300°C.

6. The nanoporous silica film of claim 20 wherein said reaction is conducted for a time period ranging from about 10 seconds to about 1 hour.

7. The nanoporous silica film of claim 20 wherein said surface modification agent is a polymer or oligomer that comprises functional groups that will react with silanols.

8. The nanoporous silica film of claim 7 wherein said surface modification agent is prepared by reacting a suitable monomer with water in a solvent to form said surface modification agent.

9. The nanoporous silica film of claim 2 wherein said solvent or co-solvent is selected from the group consisting of ethers, esters, ketones, glycol ethers, hydrocarbons, chlorinated solvents, low viscosity siloxanes and combinations thereof.

10. The nanoporous silica film of claim 2 wherein said co-solvent is selected from the group consisting of ethers, esters, ketones, glycol ethers, hydrocarbons, chlorinated solvents, low viscosity siloxanes and combinations thereof.

11. The nanoporous silica film of claim 8 wherein said monomer is selected from the group consisting of a siloxane, a silazane, a silane, a carbosilane, and combinations thereof.

12. The nanoporous silica film of claim 8 wherein said water is present in said co-solvent in a concentration ranging from about 0.05 to about 10 percent, by weight, relative to the co-solvent.

13. The nanoporous silica film of claim 8 wherein said water is present during said reaction in proportion to said monomer in a ratio ranging from about0.50:1.5 to about 1.5:0.5, mole/mole.

14. The nanoporous silica film of claim 8 wherein said monomer compound is selected from the group consisting of said monomer compound is selected from the group consisting of methyltriacetoxysilane, phenyltriacetoxysilane, tris(dimethlyaimino)methylsilane, tris(dimethylamino)phenylsilane, tris(diethylamino)methylsilane and combinations thereof.

15. The nanoporous silica film of claim 20 wherein the composition comprises an oligomer or polymer surface modification agent and a monomer surface modification agent, wherein said monomer is reactive with silanol groups on said silica film.

16. The nanoporous silica film of claim 20 wherein said silica film is pre-treated with a monomer surface modification agent, wherein said monomer is reactive with silanol groups on said silica film.

17. The nanoporous silica film of claim 8 further comprising adding at least one additional monomer to said solution after the water is fully reacted, wherein said monomer is reactive with silanol groups on said silica film.

18. The nanoporous silica film of claim 15 wherein the monomer surface modification agent is an selected from the group consisting of siloxanes, silazanes, silanes, carbosilanes and combinations thereof.

19. The nanoporous silica film of claim 15 wherein the monomer surface modification agent is selected from the group consisting of acetoxytrimethylsilane, diacetoxydimethylsilane, methyltriacetoxysilane, phenyltriacetoxysilane, diphenyldiacetoxysilane, trimethylethoxysilane, trimethylmethoxysilane, 2-trimethylsiloxypent-2-ene-4-one, n-(trimethylsilyl)acetamide, 2-(trimethylsilyl) acetic acid, n-(trimethylsilyl)imidazole, trimethylsilylpropiolate, trimethylsilyl(trimethylsiloxy)-acetate, nonamethyltrisilazane, hexamethyldisilazane, hexamethyldisiloxane, trimethylsilanol, triethylsilanol, triphenylsilanol, t-butyldimethylsilanol, diphenylsilanediol, tris(dimethylamino)methylsilane, tris(dimethylamino)phenylsilane, tris(dimethylamino)silanemethyltrimethoxysilane, methyltris(methylethylkeoxime)silane. methyltrichlorosilane, and combinations thereof.

20. A nanoporous silica film produced by a process comprising the steps of reacting a suitable silica film with a composition comprising a surface modification agent, wherein said silica film is present on a substrate and wherein said reaction is conducted under conditions and for a period of time sufficient for said surface modification agent to form a hydrophobic coating on said film and said surface modification agent comprises at least one type of oligomer or polymer reactive with silanol groups on said silica film.

21. The nanoporous silica film of claim 20 wherein a stud-test conducted on said film exhibits a film break strength of greater than 2 KPSI and a dielectric constant ranging from about 1.1 to about 3.0.

22. An integrated circuit comprising at least one nanoporous silica film treated by reacting said silica film with a surface modification agent, wherein said reaction is conducted under conditions and for a period of time sufficient for said surface modification agent to form a hydrophobic

coating on said film, and said surface modification agent comprises at least one type of oligomer or polymer reactive with silanol groups on said silica film.

23. The integrated circuit of claim 22 wherein said surface modification agent is prepared by reacting a suitable monomer with water in a solvent to form said surface modification agent.

24. The integrated circuit of claim 22 wherein said solvent or co-solvent is selected from the group consisting of ethers, esters, ketones, glycol ethers, chlorinated solvents, low viscosity siloxanes and combinations thereof.

25. The integrated circuit of claim 24 wherein said co-solvent is selected from the group consisting of ethers, esters, ketones, glycol ethers, chlorinated solvents, low viscosity siloxanes and combinations thereof.

26. The integrated circuit of claim 23 wherein said monomer is selected from the group consisting of a siloxane, a silazane, a silane, a carbosilane, and combinations thereof.

27. The integrated circuit of claim 23 wherein said water is present in said co-solvent in a concentration ranging from about 0.05 to about 10 percent, by weight, relative to the co-solvent.

28. The integrated circuit of claim 26 wherein said water is present during said reaction in proportion to said monomer in a ratio ranging from about 0.50:1.5 to about 1.5:0.5, mole/mole.

29. The integrated circuit of claim 24 wherein said monomer compound is selected from the group consisting of methyltriacetoxysilane, phenyltriacetoxysilane, tris(dimethlyaimino)methylsilane, tris(dimethylamino)phenylsilane, tris(diethylamino)methylsilane and combinations thereof.

31. The nanoporous silica film of claim 20 wherein the surface modification agent comprises a siloxane polymer/oligomer of Formula I, a silazane polymer/oligomer of Formula II, a silane polymer/oligomer of Formula III, or a carbosilane polymer/oligomer of Formula IV, wherein:

said siloxane polymer/oligomer has the formula:

(-SiXR-O-)n Formula I

wherein R is selected from H, alkyl, or aryl group and X is selected from one or more of the following moieties: H, acetoxy ($OCOCH_3$), enoxy ($CH_2=C(CH_3)$-O-Si), oxime ($R_2C=N$-Os-Si), alkoxy(RO-Si), amine(R_2N-Si) and/or silanol (Si-OH), and n is an integer ranging, from 2 to about 10,000, or greater;

said silazane polymer/oligomer has the formula:

(-SiXR_1-NR_2-)n Formula II

wherein R_1 and R_2 are independently selected from H, alkyl, and/or aryl, and X is selected from one or more of the following moieties: acetoxy ($OCOCH_3$), enoxy ($CH_2=C(CH_3)$-O-Si), oxime($R_2C=N$-Os-Si), alkoxy(RO-Si), and amine(R_2N-Si), and n is an integer ranging, from 2 to about 10,000, or greater;

said silane polymer/oligomer has the formula:

(-SiXR-)n Formula III

wherein R is selected from H, alkyl, or aryl group and X is selected from one or more of the following moieties: H, acetoxy ($OCOCH_3$), enoxy ($CH_2=C(CH_3)$-O-Si), oxime($R_2C=N$-Os-Si), alkoxy(RO-Si), and amine(R_2N-Si), and n is an integer ranging, from 2 to about 10,000, or greater; and

said carbosilane polymer/oligomer has the formula:

$(-SiR_1R_2-R_3-)_n$ Formula IV

wherein R_1 and R_2 are independently selected from H, alkyl, aryl groups, acetoxy ($OCOCH_3$), enoxy ($CH_2=C(CH_3)-O-Si$), oxime($R_2C=N-Os-Si$), alkoxy(RO-Si), or amine(R_2N-Si), and R_3 comprises a substituted or un-substituted alkylene or arylene.

32. The nanoporous silica film of claim 20 wherein the surface modification agent is selected from the group consisting of polydimethylsilane, polyphenylmethylsilane, poly(1,2-dimethylsilzane),
(1,2-dimethylsilazane)(1-methylsilazane) copolymer, N-methylsilazane resin, and combinations thereof.

33. The nanoporous silica film of claim 20 wherein the surface modification agent comprises a hydrolysis/condensation product of methyltriacetoxysilane.

34. The nanoporous silica film of claim 20 wherein the surface modification agent comprises a polyacetoxysilane, a poly(methyltriacetoxy)silane, or combinations thereof.